Artificial and Computational Intelligence

AIMLCZG557

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AIMLCZG557 – CS#1

M1: Introduction to AIMLCZG557 & AI

ACI: Disclaimer and Acknowledgements

- Few content for these slides may have been obtained from prescribed books and various other source(s) on the Internet.
- We hereby acknowledge all the contributors for their material and inputs and gratefully acknowledge people others who made their course materials freely available online. We have provided source information wherever necessary.
- We have added and modified the content to suit the requirements of the class dynamics & live session's lecture delivery flow for presentation.
- This *is not a full-fledged* reading materials. Students are requested to refer to the textbook w.r.t detailed content as per the course handout as shared over e-learning portal - Taxila.
- **Slide Source / Preparation / Review:**
- From BITS Pilani WILP**:** Prof. Rajavadhana, Prof. Indumathi, Prof. Sangeetha and Prof Parthasarathy PD
- From BITS On-campus & External : Mr.Santosh GSK

Agenda for CS #1

1) Introduction to AIMLCZG557
   - Course handout
   - Books & Evaluation components
   - How to make the most out of this course ?
2) History of AI
3) Foundations & applications & Risks of AI
4) Perspectives to Artificial Intelligence (AI)
5) Agents and Introduction to PEAS
6) Q&A!

Course Handout

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Birla Institute of Technology & Science, Pilani
Work Integrated Learning Programmes Division

Digital Learning Handout

Part A: Content Design

Course Title	Artificial and Computational Intelligence
Course No(s)	AIML ZG557
Credit Units	5
Credit Model	1.25 - 1.5 - 2.25
Course Author	Profs. Vimal SP, Raja Vadhana Prabhakar
Instructors	Prof. PD Parthasarathy, Prof Akhil PV, Prof A Raghunathan, Prof Arunkumar B, Prof Shyamala Boosi, Prof Sudheer Reddy, Prof Ramya Devi M, Prof Sandeep Patil, Prof SURYA PRAKASH Goteti
Version No:	6.0
Date:	30/03/2026

Course Description:
Agents and environments, Task Environments, Working of agents; Uninformed Search Algorithms: Informed Search. Local Search Algorithms & Optimization Problems: Genetic Algorithm; Searching with Non-Deterministic Actions, Partial Information and Online search agents, Game Playing, Constraint Satisfaction Problem, Knowledge Representation using Logics: TT-Entail for inference from truth table, Proof by resolution, Forward Chaining and Backward Chaining, Inference in FOL, Unification & Lifting, Forward chaining, Backward Chaining, Resolution; Probabilistic Representation and Reasoning : Inference using full joint distribution, Representation of Conditional Independence using BN, Reinforcement Learning; Difference between crisp and fuzzy logic, shapes of membership function, Fuzzification and defuzzification, fuzzy logic reasoning; Decision making with fuzzy information, Fuzzy Classification; Connectionist Models: Introduction to Neural Networks, Hopfield Networks, Perceptron Learning, Back propagation & Competitive Learning, Applications of Neural Net: Speech, Vision, Traveling Salesman; Genetic Algorithms - Chromosomes, fitness functions, and selection mechanisms, Genetic algorithms: crossover and mutation, Genetic programming.

Course Objectives

No	Course Objective
CO1	Identify and recall fundamental concepts and techniques for designing intelligent agents
CO2	Represent and use of knowledge in inference-based problem solving approaches
CO3	Apply probability theory to describe and model agents operating in uncertain environments
CO4	Implement optimisation models of computation and processing in real world application of intelligent agents
CO5	Apply principles of cooperative and competitive multi-agent decision making by constructing conceptual frameworks

Format No: QF.02.01 Rev:6 Dt 30 .03.26

- Local Search Algorithms & Optimization Problems: Hill Climbing Search, Local Beam Search, Evolutionary Algorithm - Genetic Algorithm, Bioinspired Algorithm - Ant Colony Optimization
- Neural Architecture Search: Introduction, Neuro Evolution

4. Game Playing:
   - Searching to play games: Minimax Algorithm, Alpha-Beta Pruning
   - Monte Carlo Tree Search
   - Stochastic Games
5. Knowledge Representation using Logics:
   - Overview of Logics- Propositional, Predicate, TT-Entail, Theorem Proving
   - Logic Representation of a sample agent, Proof by resolution, DPLL Algorithm, Agents based on Propositional logic
   - Unification, forward chaining, Backward Chaining, Resolution
6. Multi agent Decision Making:
   - Multi agent Planning: Properties of Multi agent environments
   - Non-Cooperative Game Theory
   - Cooperative Game Theory
   - Making Collective Decisions
7. Probabilistic Representation and Reasoning
   - Representing Knowledge in an Uncertain Domain
   - The Semantics of Bayesian Networks
   - Exact Inference in Bayesian Network
   - Approximate Inference in Bayesian Networks
8. Probabilistic Reasoning over time
   - Time and Uncertainty
   - Overview of inference in Temporal Models - Hidden Markov Models - Learning HMM
   - Dynamic Bayesian Networks
9. Ethics in AI
   - Explainable AI- Logically Explained Network, Explainable Bayesian Network

Part B: Learning Plan

Contact Session	List of Topic Title	Sub-Topics	Reference
1-a)	**Introduction**	• What is Artificial Intelligence: Acting Humanly, Thinking humanly, Thinking rationally, Acting Rationally • Foundations of AI , Brief Overview of Modern AI & Application Domains.	T1: 1.1 T1: 1.2, 1.4, 1.5
1-b)	**Introduction to Intelligent Agents**	• Intelligent Agents: Notion of Agents and Environments,	

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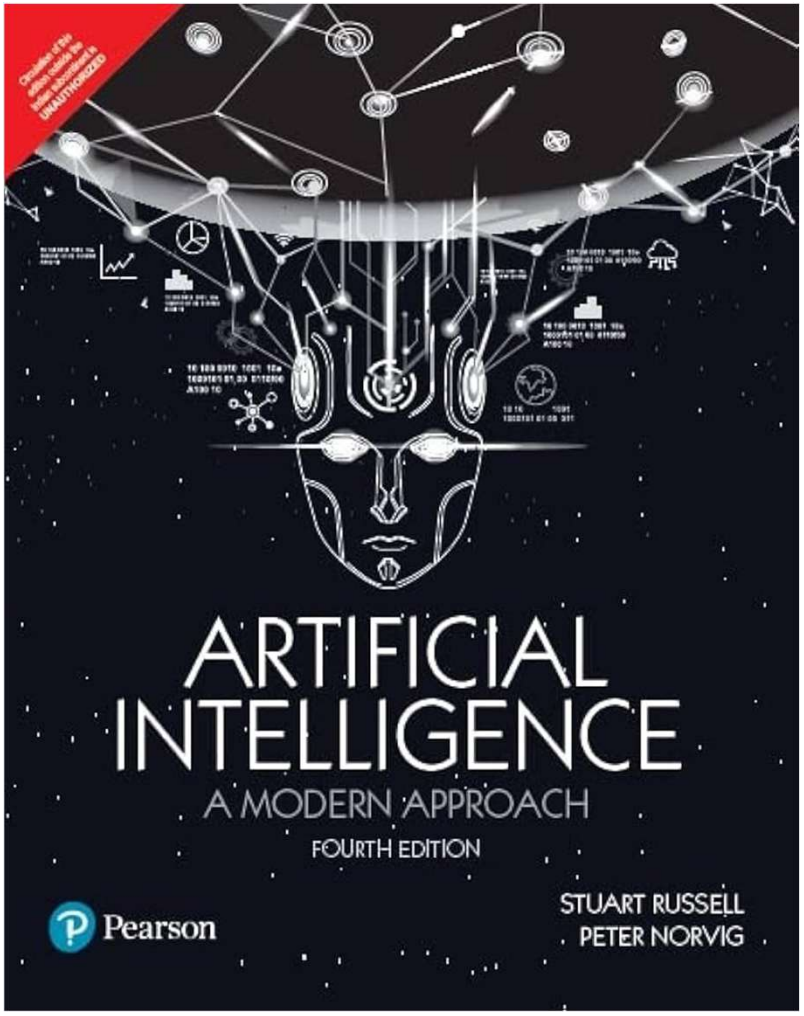
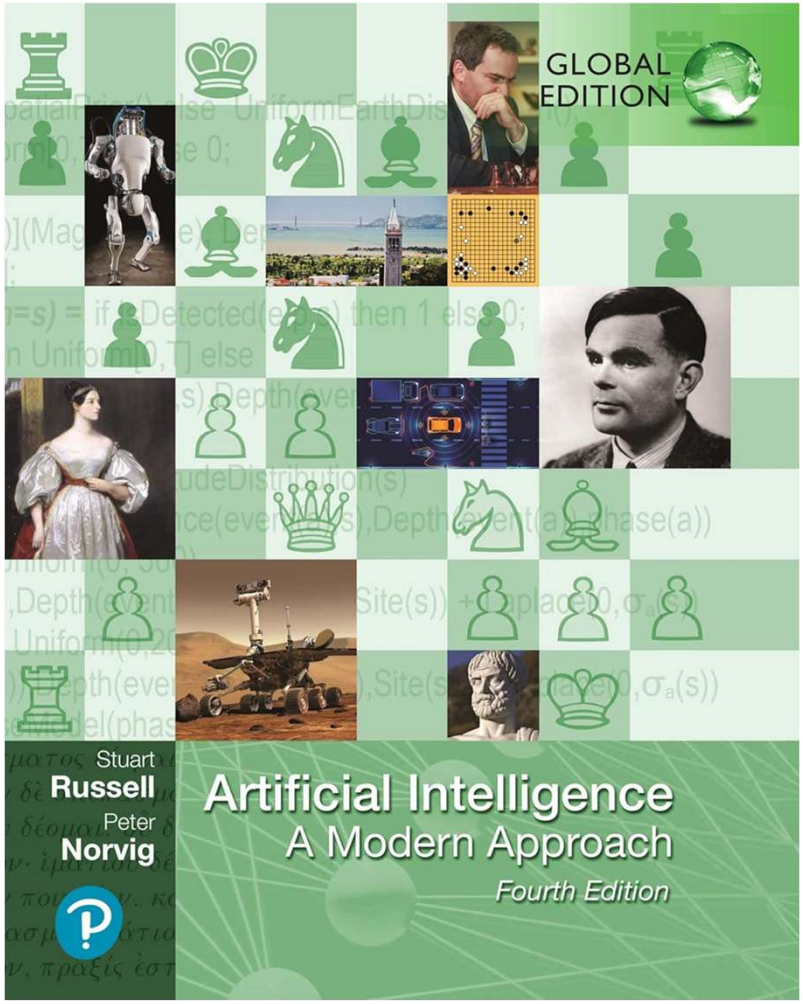
Available in eLearn Course homepage: Course Handout

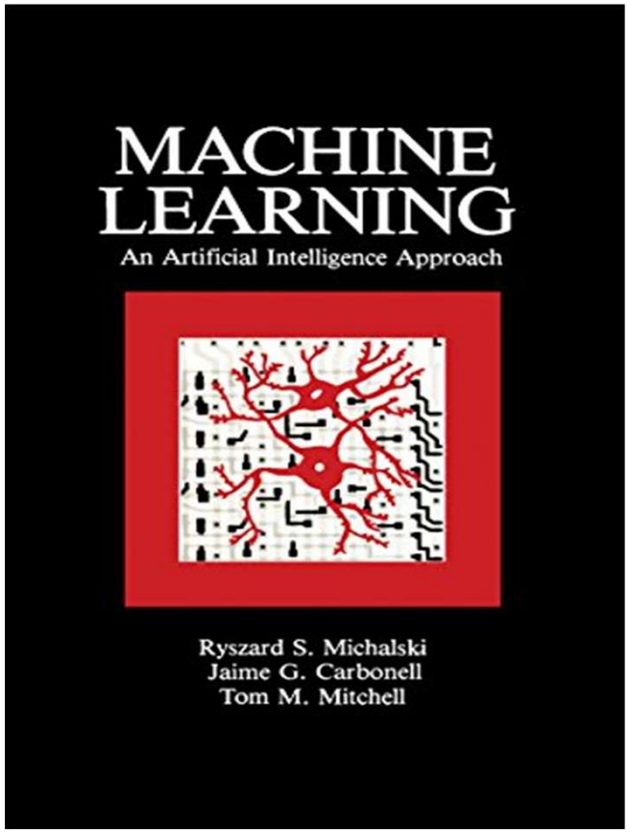
Text Book



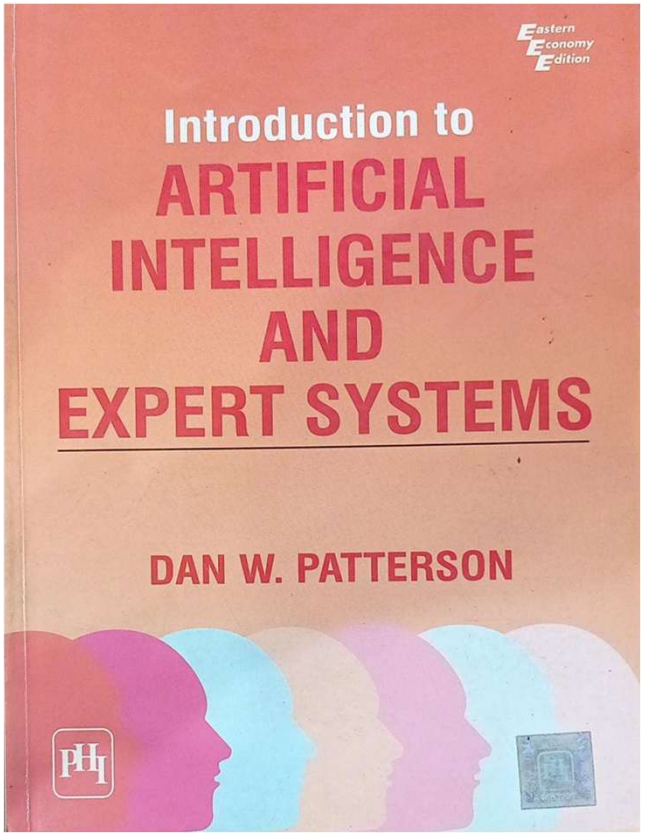


T1: Stuart Russell and Peter Norvig, "*Artificial Intelligence – A Modern Approach*", **Fourth** Ed, Pearson Education, 2022

Reference Books

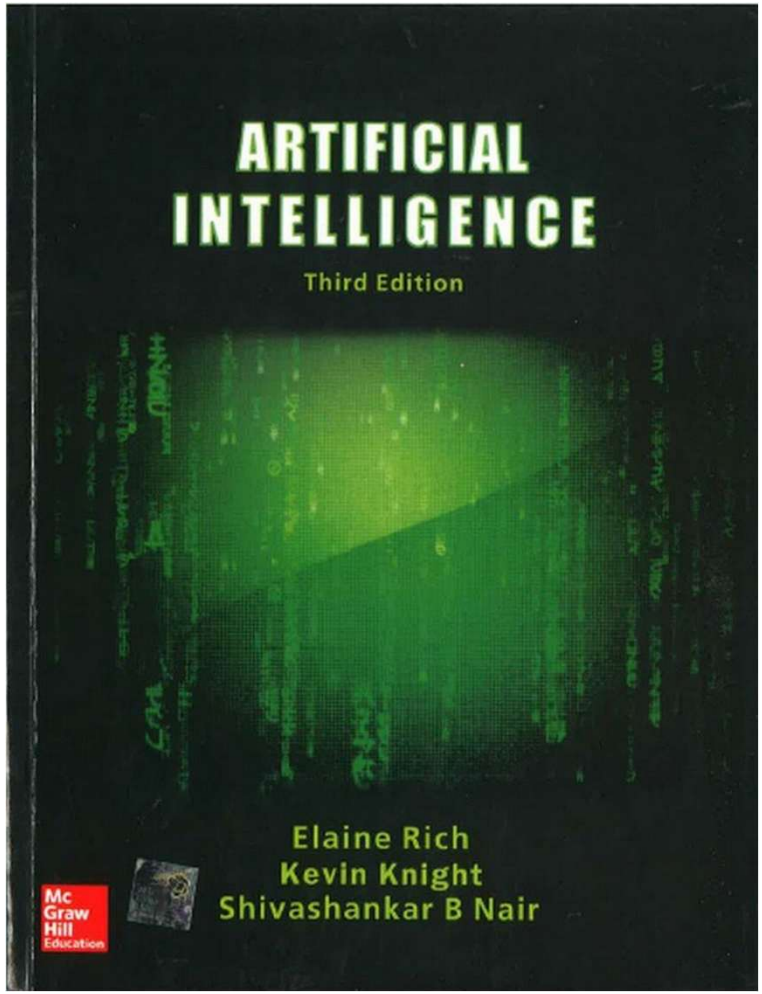


R1: Ryszard S. Michalski, Jaime G. Carbonell and Tom M. Mitchell, "*Machine Learning: An Artificial Intelligence Approach*", Elsevier, 2014



R2: Dan W Patterson, "*Introduction to AI and Expert Systems*", Prentice Hall of India, New Delhi, 2010

Reference Books



R3: Elaine Rich and Kevin Knight, Shivashankar B Nair, "*Artificial Intelligence*", 3rd Ed, Tata McGraw Hill Publishing Company.

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Evaluation Components

- EC1: Continuous assessment (**30marks**)
  - Assignment 1 – 12marks (Before mid-semester exam)
  - Assignment 2 – 13marks (After mid-semester exam)
  - Quizzes (Best of 2) – 5marks (1 before and 1 after mid-semester)
- EC2: Mid-semester examination (**30marks**)
  - Topics covered from CS#1 to CS#8
- EC3: Comprehensive final examination (**40marks**)
  - Topics covered from CS#1 to CS#16

Watchout for TAXILA announcements for evaluation dates. No extension on deadlines will be entertained.

Ground Rules!

- Be Regular
- Mentally present – Observe!! Listen!!
- Keep your questions for the Q&A section …
- Use the Discussion Forum in Taxila effectively
- Solve the exercises regularly!
- Go an extra mile ☺

$$1^{365} = 1$$

$$1.01^{365} = 37.8$$

Pre-requisites for this course ?

Class Requirements:

- Uses a variety of skills / knowledge:
- Probability and statistics
- Boolean logic
- Algorithms
- Above average coding skills

Official Pre-requisites:

- Data Structures

Unofficial Pre-requisites:

- Willingness to learn whatever background you are missing 😉

What is this course about ?

Focus on:

- Philosophy of Artificial Intelligence (AI)
- Introduction to '*breadth*' of ideas/concepts in AI
- Principles of artificial intelligence
- Concepts, and algorithms involved in building rational agents
- Topics covered like:
  - (informed, uninformed & local) search & optimizations & applications
  - (logical & probabilistic) knowledge representation
  - (logical & probabilistic) Reasoning & applications
- a bit of learning (reinforcement learning)
- a bit of *ethics* in AI

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What is this course *not* about ?

- Hardware aspect of design
- Formal introduction to machine learning algorithms, neural networks etc., are covered as a ML course is running in parallel, Deep neural networks, which are part of AI as well.
- Deeper applications & algorithms of application of AI in Computer Vision, Natural Language.
- While we talk about rational and various types of agents in this course. This is NOT a course on Agentic AI (MCP, LLMs, Tool Calling etc.)!

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Andragogy / Pedagogy

- Weekly online live sessions (with recordings).
- Four Webinars (with recordings) on lab implementation and problem solving.
- Lab Modules: Self practice lab capsules for practical implementation and better understanding of concepts learned in live lectures available via virtual lab.
- Learning is a social activity. Peer to Peer interaction and learning is very important, particularly in WILP setting:
  - Weekly "Think" topics posted on Taxila in Discussion for students to think, discuss in the forum.
  - This will be used to calculate "engagement" points and a leaderboard will be created.
  - At the end of the semester, the top 'k' members of the leaderboard will receive non-academic surprise! Maybe an AI comic? AI book? An opportunity to work on a research project with a BITS faculty? Or watch an AI sci-fi movie!

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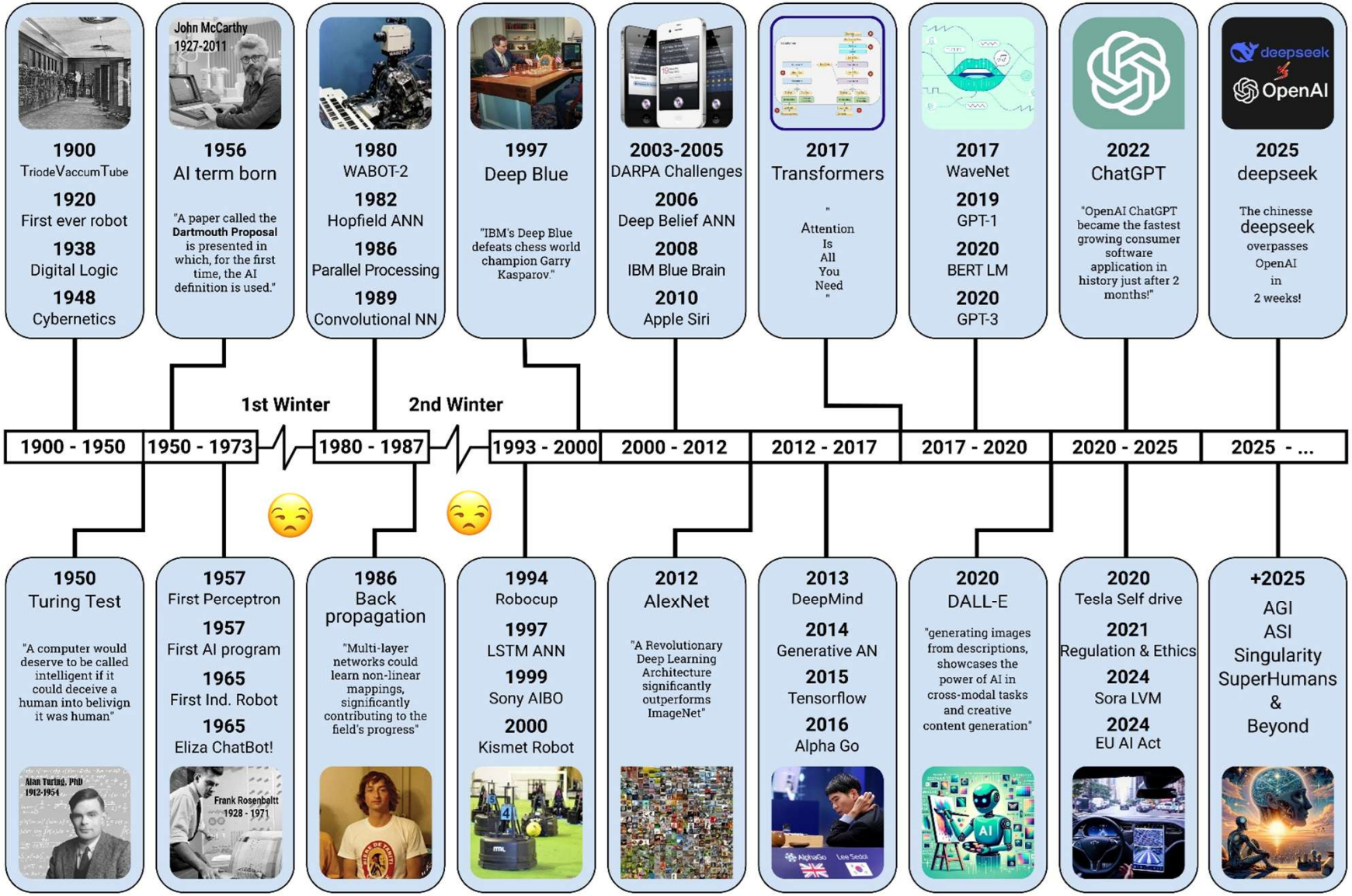
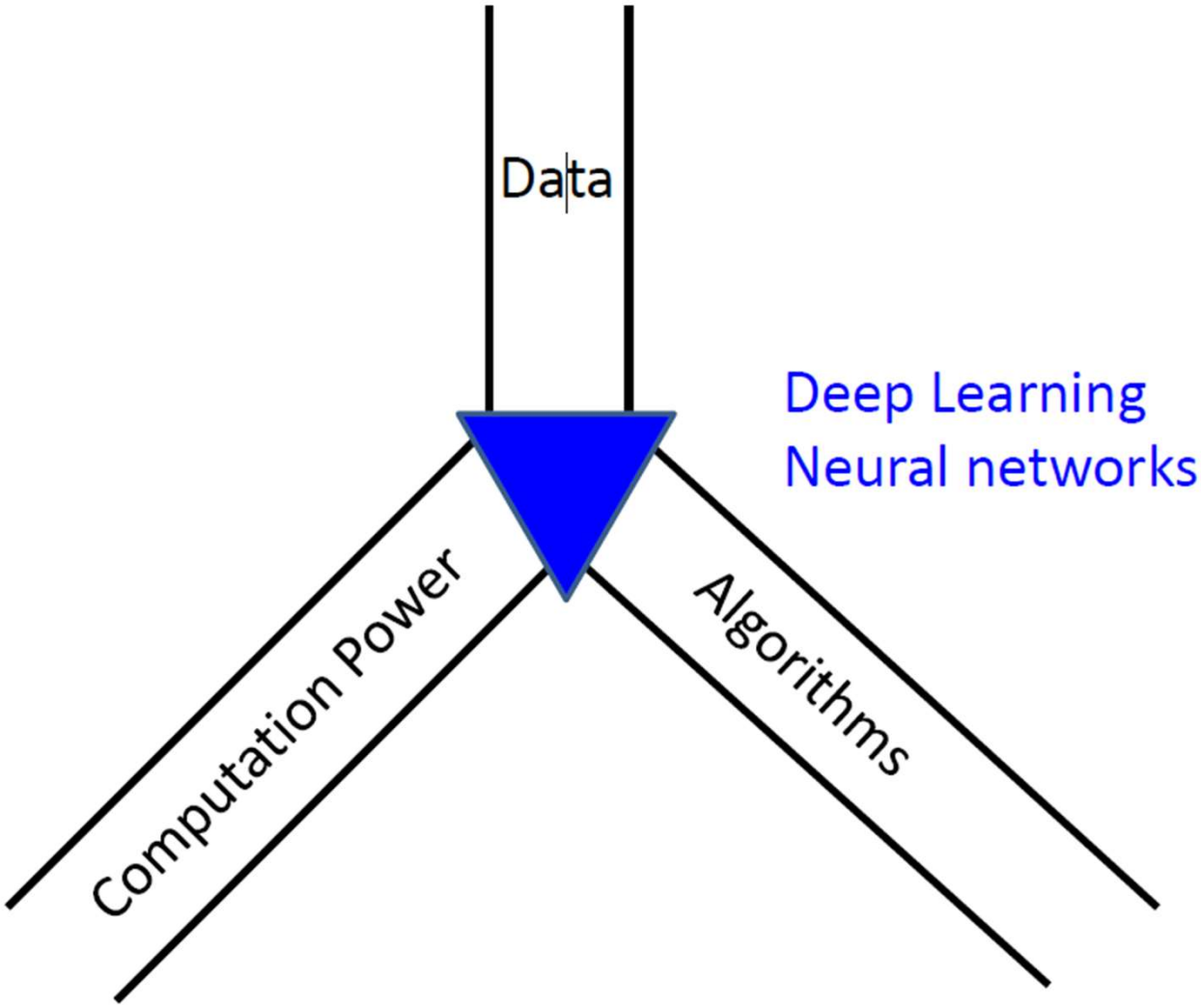
History of AI



What Changed in the last Decade?



AI Boon or Bane Debate …

AI Application Areas

- Healthcare
- Finance
- Education
- Automotive
- Retail
- Manufacturing
- Customer Service
- Natural Language Processing (NLP)
- Computer Vision
- Robotics
- Smart Cities
- Agriculture
- Entertainment
- Cybersecurity
- Environmental Conservation
- Culinary
- Transportation
- …
- ……

Can you give one example in each area how AI is used?

Areas Contributing to AI

Philosophy
Mathematics
Economics
Neuroscience
Psychology
Computer Engineering
Control theory, Cybernetics
Linguistics

Glance Textbook, T1: Section 1.2 to know more!

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Foundations of AI

- Philosophy
  - Logic, method of reasoning
  - Mind as a physical state that operates as a set of rules
  - Foundations of learning, language, rationality
- Mathematics
  - Logic (propositional, first order etc.), formula representation and proof
  - Computation, algorithms
- Economics
  - Formal theory of rational decisions
  - Combined decision theory and probability theory for decision making under uncertainty
  - Game Theory and Markov Decision process
- Neuroscience
  - Study of brain functioning
  - How brains compare to computers
- Psychology
  - How do we think and act?
  - Cognitive psychology – perceives the brain as an information processing machine
  - Cognitive science – How can computer models be used to study language, memory and thinking from a psychology perspective
- Computer Science
  - Delves into how to build powerful machines to make AI possible
  - Rapid advancement in computational processing power

What is intelligence?

- Dictionary.com: *capacity for learning, reasoning, understanding, and similar forms of mental activity.*
- Ability to perceive and act in the world
- *Reasoning*: proving theorems, medical diagnosis
- *Planning*: take decisions
- *Learning and Adaptation*: recommend movies, learn traffic patterns
- *Understanding*: text, speech, visual scene

Intelligence vs. humans

- Are humans intelligent?
  - replicating human behavior early hallmark of intelligence
- Are humans always intelligent?
- Can non-human behavior be intelligent?

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What is *artificial* intelligence?

human-like *vs.* rational

thought *vs.* behaviour

Thinking Humanly "The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	**Thinking Rationally** "The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly "The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	**Acting Rationally** "Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998) "AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

What is *artificial* intelligence?

human-like *vs.* rational

thought *vs.* behaviour		
	Systems that think like humans	Systems that think rationally
	Systems that act like humans	Systems that act rationally

	Human Performance	**Rational Performance**
Thought/ Reasoning	(1) Thinking Humanly	(3) Thinking Rationally
Acting	(2) Acting Humanly	(4) Acting Rationally

(1) Thinking Humanly : Cognitive Modelling Approach

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- Uses Cognitive Science
  - Very hard to understand how humans think.
  - Usually we use post-facto rationalizations, irrationality of human thinking.
- How do we capture human thinking ?
  - Introspection
  - Psychological experiment's
  - Brain imaging
- Do we want a machine that beats humans in chess or a machine that *thinks like humans* while beating humans in chess?
  - Deep Blue supposedly *DOESN'T* think like humans..

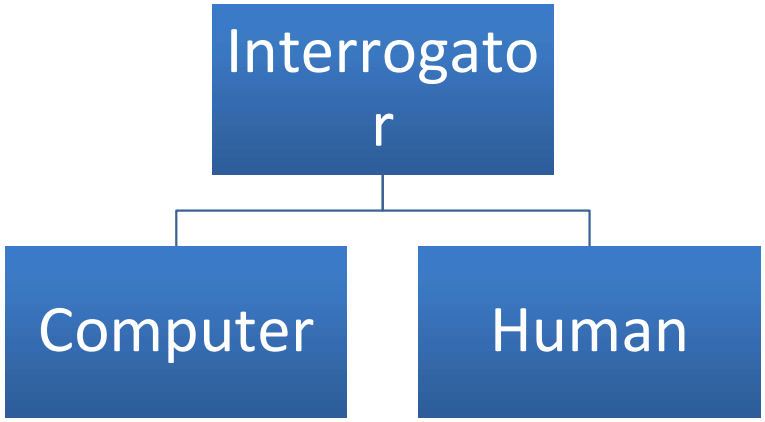
Aeronautical engineering texts do not define the goal of their field as making "machines that fly so exactly like pigeons that they can fool even other pigeons!"

(1) Thinking Humanly : Cognitive Modelling Approach (Contd..)

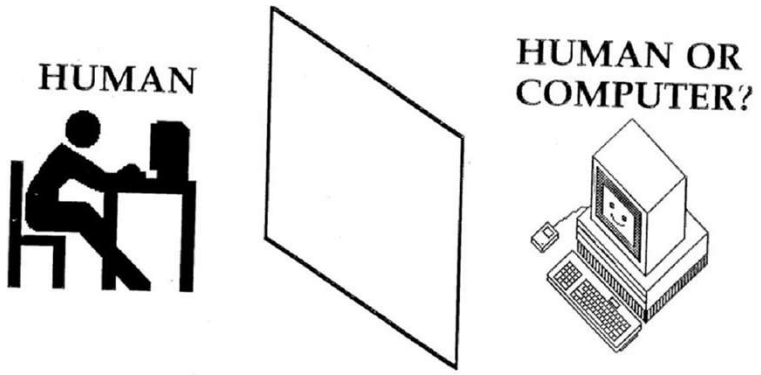
- Thinking like humans important in Cognitive Science applications
  - Intelligent tutoring
  - Expressing emotions in interfaces… HCI
- Growth of Cognitive science and AI supports each other.
- "General Problem Solver" (Newell and Simon, 1961)
  - Designed to work as a universal problem solver
  - Problems represented by horn clauses
  - First AI Machine which has KB + Inference separation
  - Authors focus on this is on comparing the trace of its reasoning steps to traces of human subjects solving the same problems

(2) Acting Humanly : Turing Test Approach

- It is about creating machines that can act or perform tasks which would require intelligence when performed by people.
- Assume you have built a machine that can Act Humanly.
- Now, let us test it!
- Turing Test



If the human/interrogator cannot tell whether the responses from the other side of a wall are coming from a human or computer, then the computer is intelligent.



(2) Acting Humanly : Turing Test Approach (Contd..)

- Skills necessary to pass these tests:
  - NLP, Knowledge Representation, Automated Reasoning, ML + Computer Vision & Robotics (for total turing test).
- Loebner Prize
  - Every year in Boston
  - Expertise-dependent tests: limited conversation
- Chabot - Eugene Goostman - Pretended to be a thirteen-year-old Ukrainian boy:
  - Passed the turing test for the first time! 10/30 Judges believed the response is from human
- What if people call a human, a machine?
  - Shakespeare expert / Shakuntala Devi!
  - Make human-like errors
- Problems
  - Not reproducible, constructive or mathematically analyzable

(3) Thinking Rationally : Laws of Thought Approach

- *Aristotle*: what are correct arguments/thought processes? Logic!
- Invention of Formal Logic, Greek Philosopher Aristotle, Third century BC.
- Introduced syllogisms, providing argument structures..

In all boring classes, students sleep

It is a boring class

Students sleep in this class [Are you ?]

- Field of Logics gave rise to *codifying* rational thinking
  - When elements are 'things', we reason about things
- Problems? (1) Not all intelligent behavior is mediated by logical deliberation (reflexes) (2) It is computationally exhaustive to build systems even with a few hundred facts. Hence, such systems are not scalable.

(4) Acting Rationally: The Rational Agent Approach

- Acting Rationally is about building *Rational Agents*.
- An agent is an entity that perceives and acts! (This course is majorly about designing rational agents).
- Agent – Something which acts, i.e., performs an action on the environment.
- *Rational Agent* - One that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome
- Computational limitations make perfect rationality unachievable.
- Design best program for given machine resources

(4) Acting Rationally: The Rational Agent Approach (Contd..)

- Rational behaviour: doing the *right thing*
- The *right thing*: that which is expected to maximize goal achievement, given the available information
- Rationality can include
  - Correct inference – using logical reasoning to perform action in order to achieve a goal, e.g., when to brake a car
  - Make an inference even when there is no correct inference, e.g., predicting an action in self-driving car during an accident to minimize life damage
  - Acting without inferring (need not always be deliberative), e.g., recoiling from a hot stove is a reflex action without inference
- Rational behaviour is not just about correct inference / thinking, skills needed to pass turing test etc.

Thank You for your time & attention !

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